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Technical Memorandum 3-63

RESPONSE LATENCIES IN THE RHESUS MONKEY AS A FUNCTION OF TONE INTENSITY

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HUMAN ENGINEERING LABORATORIES

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ABSTRACT

An analysis was made of response latencies of four young-adult, audiometric-test-sophisticated Rhesus monkeys to near-threshold two-kilocycle stimulus tones. The animals were restrained during the test, and headphones were used to deliver the tone. Equal log unit decreases in stimulus intensity produced a positively accelerated response latency curve for the group. Variances tended to increase logarithmically with a decrease in stimulus intensity, though variability was consistent throughout the ten days of testing within each intensity level. Latency measurements provide an objective indication of "goodness of performance" during sensory threshold testing of animals.

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INTRODUCTION

As avoidance training progresses, response latencies normally decrease. In the early avoidance training of monkeys for auditory acuity experiments at the Human Engineering Laboratories, response latency has been used -- though only on a non-formalized basis -- as one of several indicators of an animal's readiness for audiometric training and testing. But latencies also increase near the threshold. Harris (2), in his study of auditory acuity of monkeys, used this latter effect to simplify his testing procedure.

The purpose of this experiment is to determine how response latencies depend on stimulus intensity.

METHOD

Subjects

The animals tested were four young-adult, female Rhesus monkeys. In addition to undergoing at least three months of training, three animals (nos. 51, 54, and 56) had experienced more than 90 sessions of auditory acuity testing; the fourth (no. 71) had been given at least 60 such sessions. Animals 51 and 54 had been subjects in a study of noise impulse effects six months prior to the collection of data for this study. Both had recovered fully from the hearing losses sustained during these exposures.

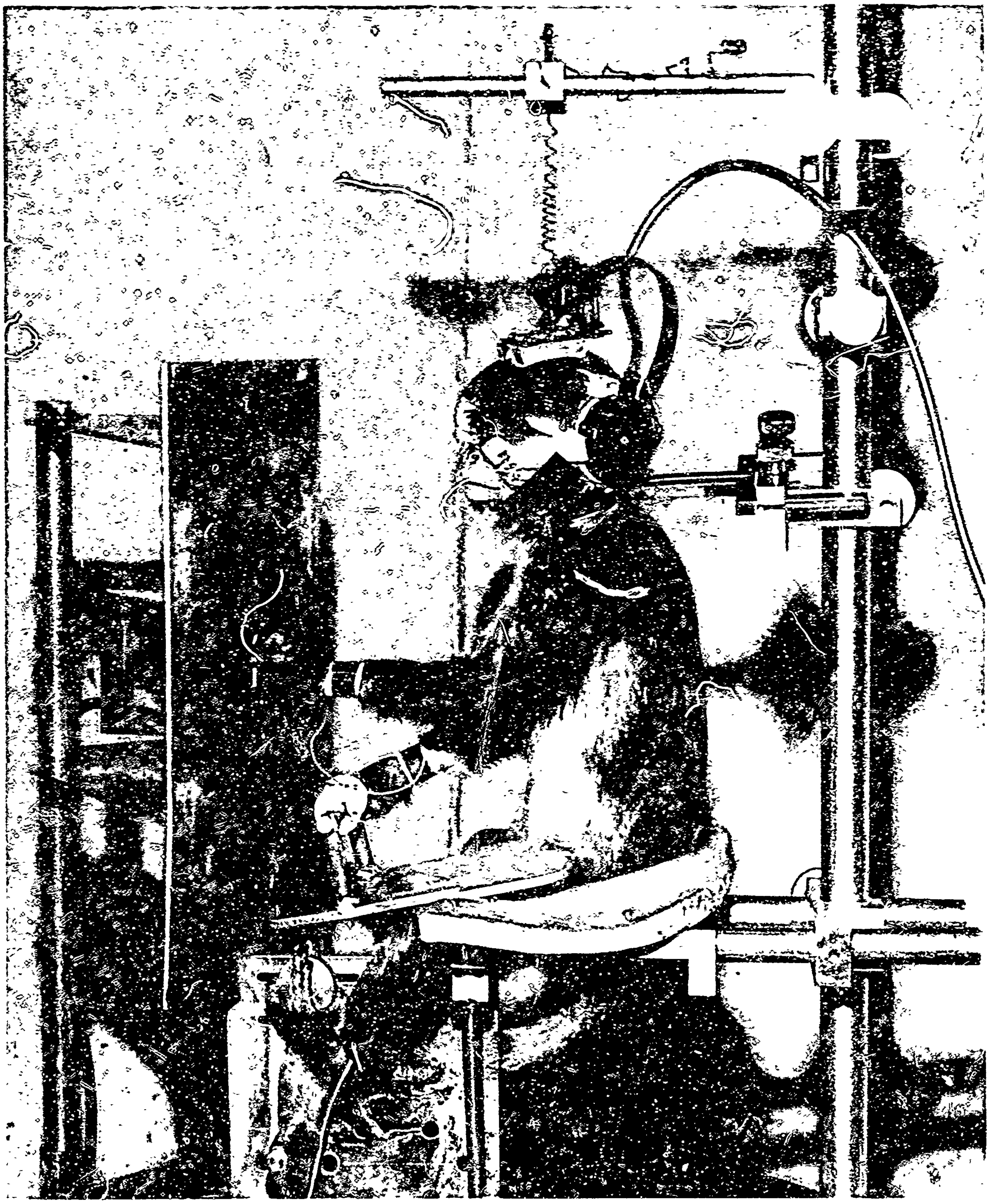

Figure 1. Experimental test arrangement for obtaining response latencies to a tone signal.

Apparatus

A complete description of the audiometer and its components has been reported (3). The audiometer was calibrated eight months prior to this study. The calibrating system was the Bruel and Kjaer (B&K) artificial ear, type 4151, with the NBS coupler, on which was mounted a 30 cc. animal ear cushion and a Beyer Dynamic Headset, DT 48. The measured deviation for the two-kilocycle tone used in this experiment was less than one decibel.

The position of the earphone was kept constant -- approximately 1-1/4 inches from the animal's ear -- during the experiment by using a phone-holding helmet device. A good helmet fit was assured by foaming its inner surface with a rubber-like material to conform to the shape of each animal's head.

Trial programming equipment consisted of a series of relays and timing circuits. An electronic switch simultaneously turned on the tone and a standard electric timer, calibrated in 10-millisecond intervals. The timer could be stopped in two ways: by a signal from contact closure at a response lever in the test room, or, if this signal did not occur after five seconds, from the programming equipment.

PROCEDURE

For each session, the animal was restrained in the test room, as illustrated in Figure 1. A short warm-up period, consisting of eight to ten trials, was completed before the test began.

During all testing, the animal's lever pressing served as the indicator of stimulus detection. In general, the trial events followed this sequence: (1) a ready signal, which was a sudden reduction of ambient light intensity, that prepared the subject to listen for a tone; (2) an interval of one second before the tone was presented; and (3) a four-second tone presentation. The increase of ambient illumination to normal signalled the end of the trial.

A constant interval between the onset of the "ready" signal and the tone requires the use of frequent checks on the subjects' "honesty" to avoid formation of temporal discriminations. This check was done with "blank" trials which consisted of the same ready signal followed by a five-second interval during which no tone was presented.

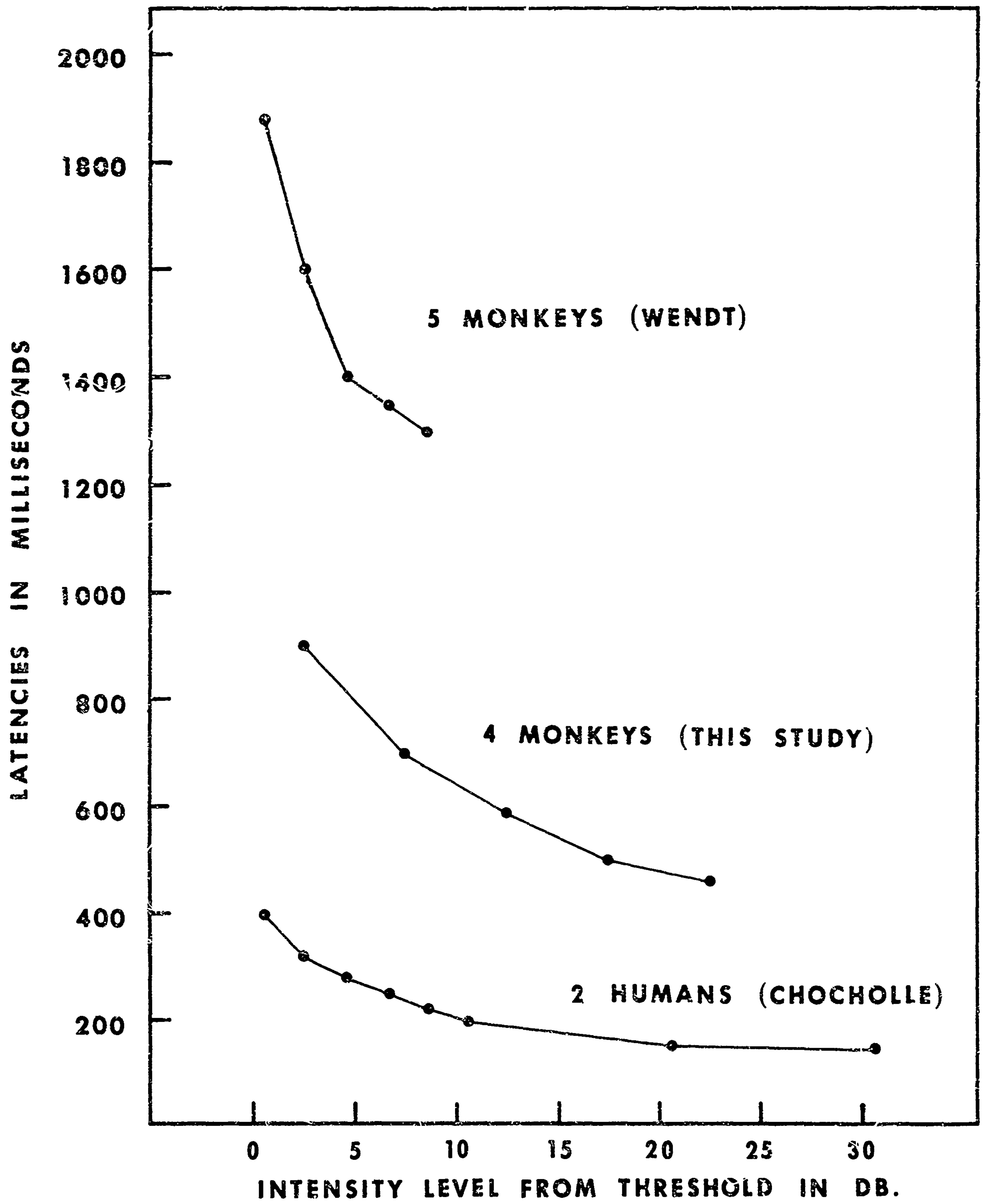

Figure 2. Comparison of latency data obtained in this study with that obtained by Wendt and Chocholle for intensities approaching threshold.

Punishment -- a mild electric shock (2.5 milliamperes) -- was given for any response made during a trial interval without tone. Inter-trial responses were not punished.

Ordinarily, no shock was administered for failure to respond, since it was presumed that if sophisticated animals did not respond, the tone must have been below their threshold. However, to keep the animal alert, it was shocked once or twice per session when it did not respond to a subliminal tone.

Consider a typical trial in detail. The experimenter depressed a button on a control box, automatically activating the entire trial sequence through the programming equipment. If a tone was scheduled for a particular trial, the experimenter pushed another button on the audiometer one second after the trial began; he released it when a response was made, or after four seconds if no response was made. Operating the tone pushbutton also started the timer, but the timer was stopped either by a lever-pressing response or at the end of the trial, by the programming equipment.

The experimental design was based on the method of limits. The sequence of intensities began at the 35-decibel (dB) level (re: .0002 ubar), decreasing in steps of five dB on successive trials until a level was reached where the animal failed to respond. The next sequence was given in ascending order, starting at the dB level just below the one just given and continuing until a level was reached where the tone was heard. One more trial, at the next higher level, was given to complete the ascending series.

In this manner, 18 threshold determinations were obtained during each of ten daily sessions. All thresholds were measured at a frequency of 2 kilocycles, using the subjects' left ears. "Blank" trials were programmed into each session in the ratio of one to each ten tone trials. The inter-trial interval was five seconds. The acuity thresholds and latencies were recorded manually.

RESULTS

Equal log unit decreases in stimulus intensity produced a positively accelerated response latency curve (Fig. 2). This function is similar to those reported by Wendt (4) for five monkeys and by Chocholle (1) for two humans. The differences in average latency levels among these studies are probably largely due to differences in individual experimental technique. The shock avoidance response used here seems to increase the speed of response. In making this response, the animals

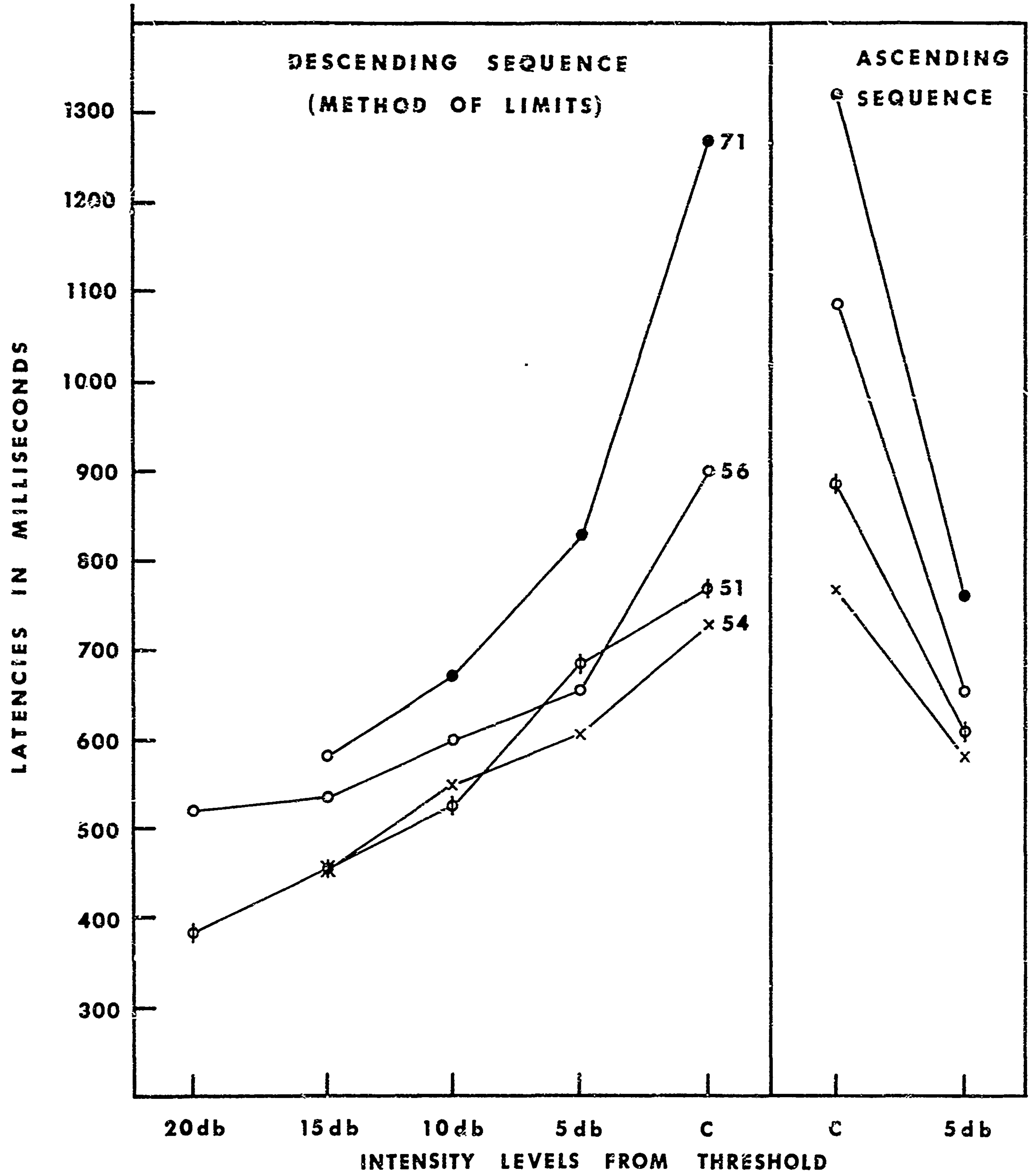

Figure 3. Mean latencies for each animal as a function of intensity level.

most frequently moved their hands approximately six inches from a bar, conveniently grasped between trials, to the lever.

Means for individual animals are given in Figure 3, plotted on a psychophysical stimulus scale. That is, in a particular sequence of trials, the smallest physical intensity level which elicited a response was designated the criterion level (CL); the next higher intensity level in the physical scale became the criterion level plus five decibels (CL + 5 dB); the next, criterion level plus ten decibels; and so on, until all levels in this sequence were identified in terms of the criterion scale. For the descending-intensity sequences, animals 71 and 56 most closely approximated the near-threshold, positively accelerating latencies observed in typical group behavior. But the average latencies shown by animals 51 and 54, again on the descending series, are best described as increasing linearly. The direction of the series (ascending or descending) affected the results, especially at the criterion levels -- CL(D) and CL (A). The smallest stimulus intensity heard in the descending sequence -- CL(D) -- consistently resulted in lower mean latencies than for the ascending procedure -- CL(A).

The variances tended to increase in a logarithmic manner with a decrease in stimulus intensity (Fig. 4). Except for one instance (in the data of animal 51) a comparison of any two adjacent criterion levels shows a greater variance for the lower level. Table 1 shows the probabilities of obtaining differences as great as these between any two successive levels, in either the ascending or descending sequence of trials, as well as between corresponding criterion levels of both sequences.

All latency values obtained in the experiment, together with daily mean threshold values, are given in Figures 5, 6, 7, and 8. The latencies are grouped by criterion levels, where CL is momentary threshold, CL + 5 dB is the next higher intensity level, etc. Data for both series -- the nine ascending stimuli and the nine descending stimuli -- are shown for each of the ten testing sessions After the fourth day, animal 51 developed a response which precluded the collection of further latency measurements. This animal tended to keep the lever depressed between trials, so that, when a tone trial was given, latencies were timed between the animal's releasing the lever and depressing it again. No data are given for these latter sessions.

Animal 71 showed the greatest day-to-day variation in latency. Its mean low was 691 milliseconds, which occurred on day seven, and the mean high was 1257 milliseconds, observed on day ten. The level CL(D) + 15 dB was not included in this mean because of incomplete data. But on any given day, the relationship between latency and the tone intensity was the same: the levels closest to threshold tended to give higher latencies. This was the only animal of the four which showed a significant increase in latencies as the testing continued during sessions. Animals 71 and 51 showed less over-all consistency and greater variability throughout the experiment than the other two subjects did. Animals 54 and 56 gave latencies which, with a few exceptions, were generally within 100 milliseconds limits for the higher intensity levels.

Mean daily thresholds, with the day's high and low measured thresholds, are given each animal's series of latency values. There is no obvious relationship between threshold levels and patterns of latency values. Generally, the daily thresholds for each animal varied within five decibel limits.

TABLE 1

Summary of *t*-Tests for Differences

Between Psychophysical Intensity Levels

COMPARISONS	*t*-Values Animal 51	Animal 54	Animal 56	Animal 71
CL(D) + 15 dB vs. CL(D) + 10 dB	3.01**	----	0.53	----
CL(D) + 10 dB vs. CL(D) + 5 dB	5.27**	7.24**	0.71	16.40**
CL(D) + 5 dB vs. CL(D)	0.36	3.79**	16.25**	6.88**
CL(A) + 5 dB vs. CL(A)	13.77**	6.32**	16.86**	7.08**
CL(A) vs. CL(D)	5.77**	3.70**	2.66**	0.12
CL(A) + 5 dB vs. CL(D)	6.40	5.49**	2.18*	0.25

* $P < .05$
** $P < .01$

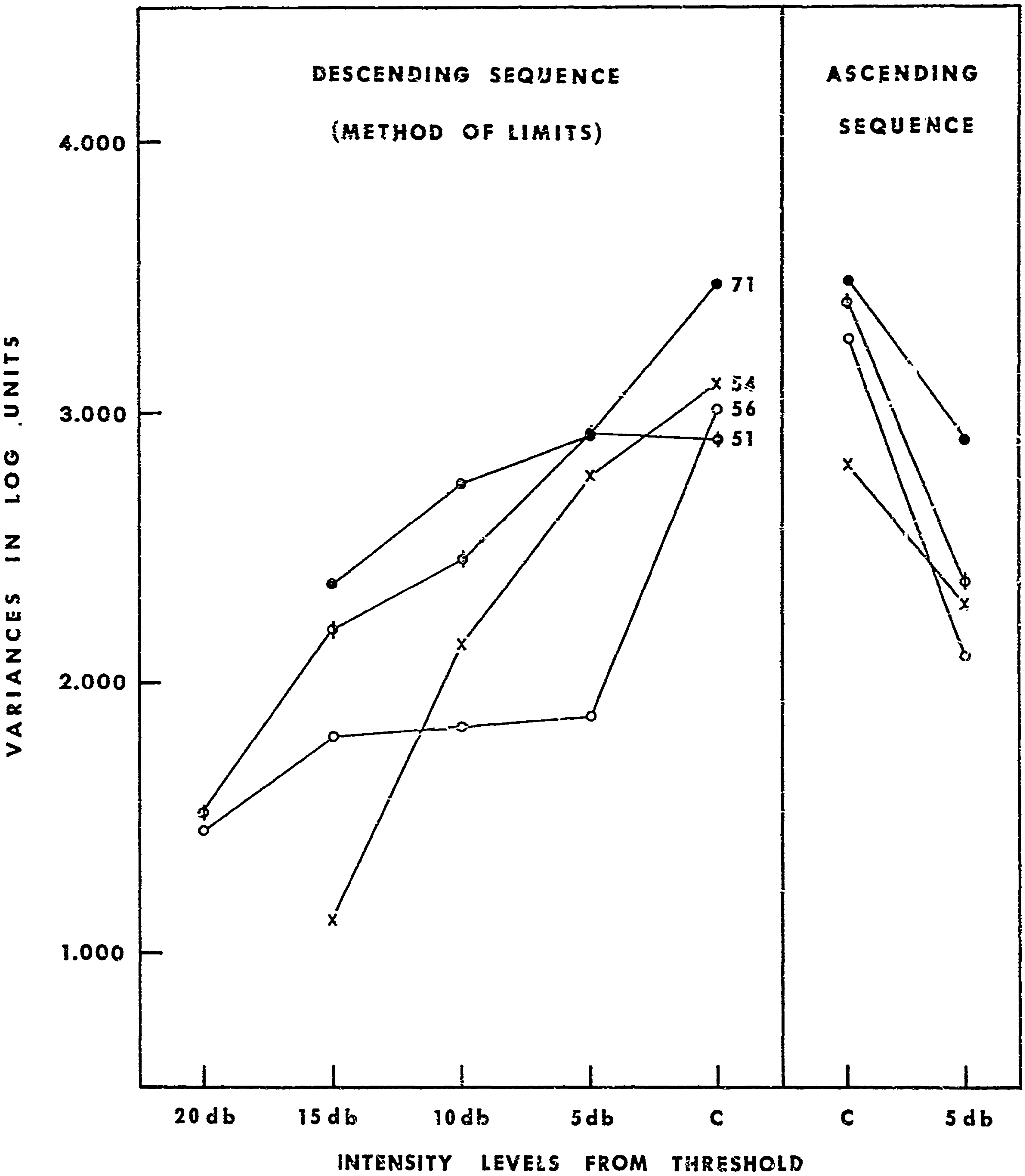

Figure 4. Average log variances as a function of intensity.

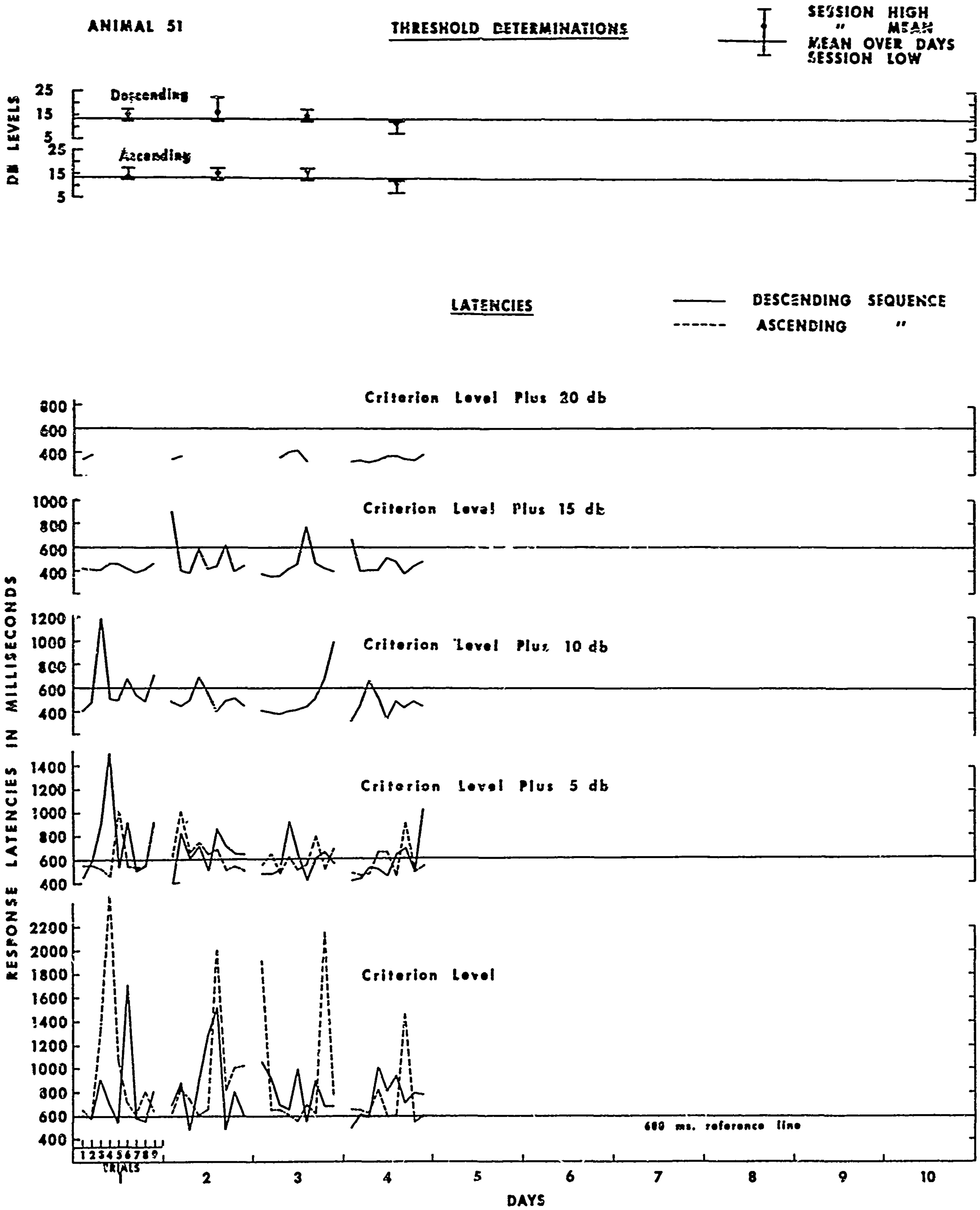

Figure 5. Threshold determinations and latencies of response for successive intensity levels, animal 51.

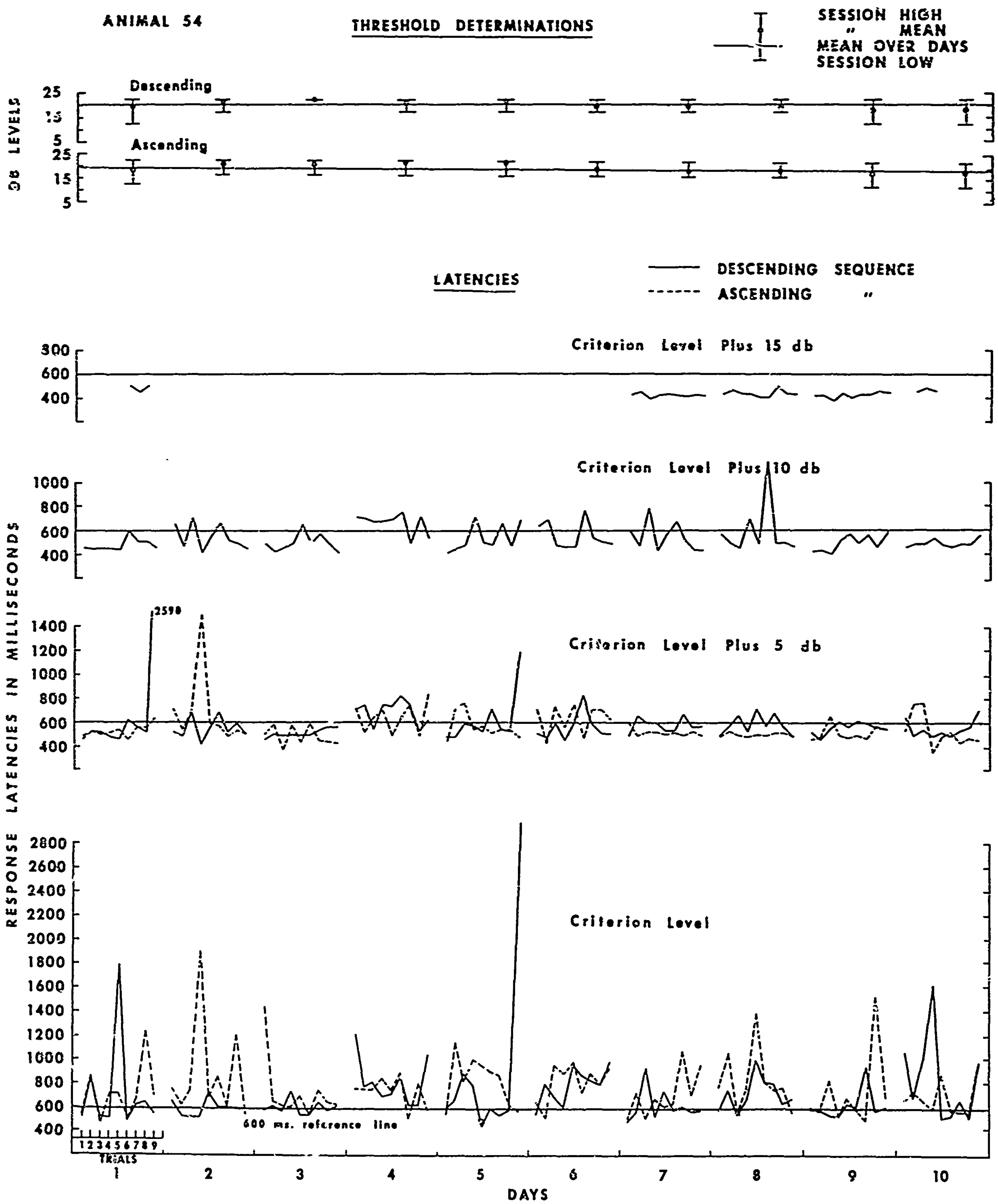

Figure 6. Threshold determinations and latencies of response for successive intensity levels, animal 54.

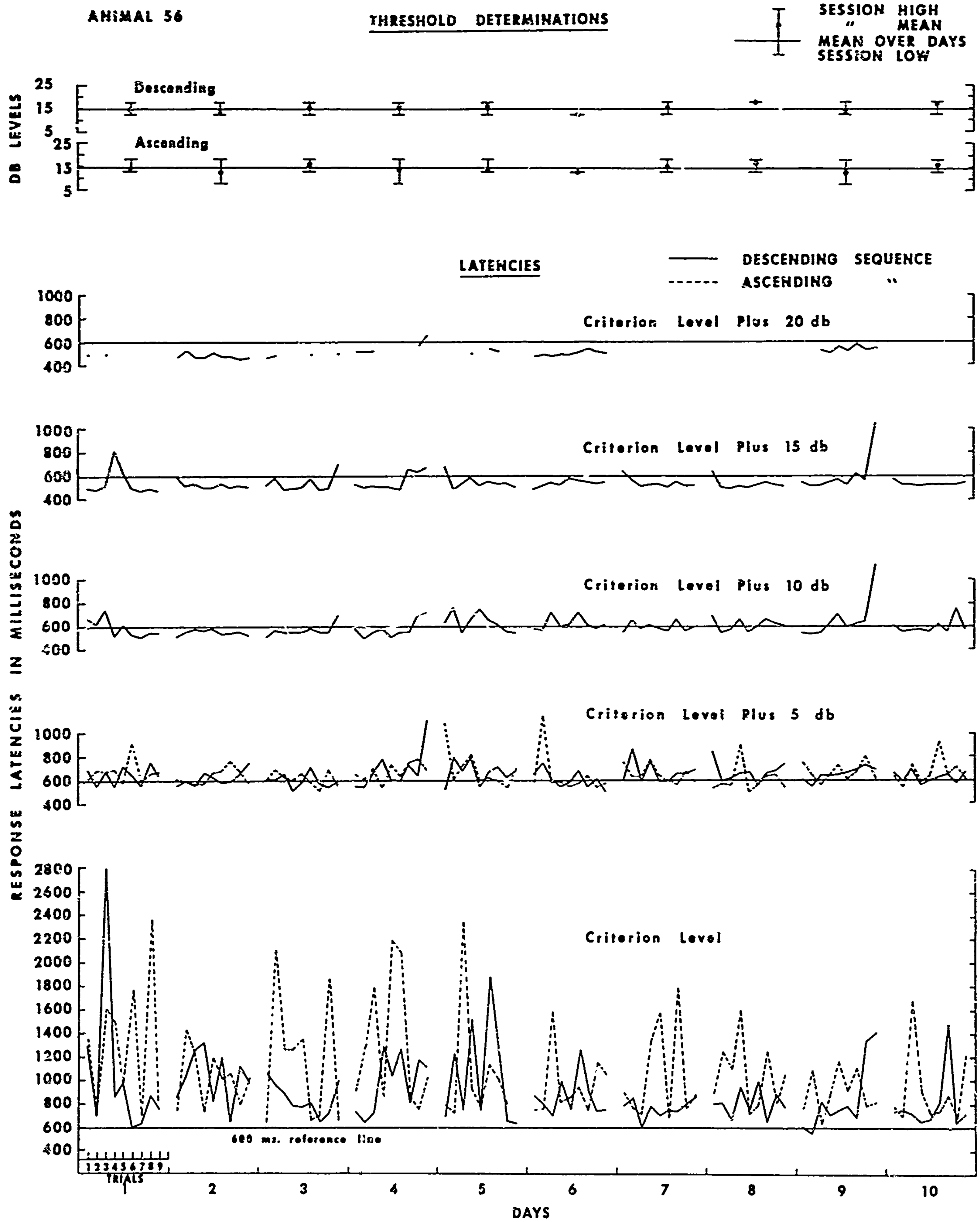

Figure 7. Threshold determinations and latencies of response for successive intensity levels, animal 56.

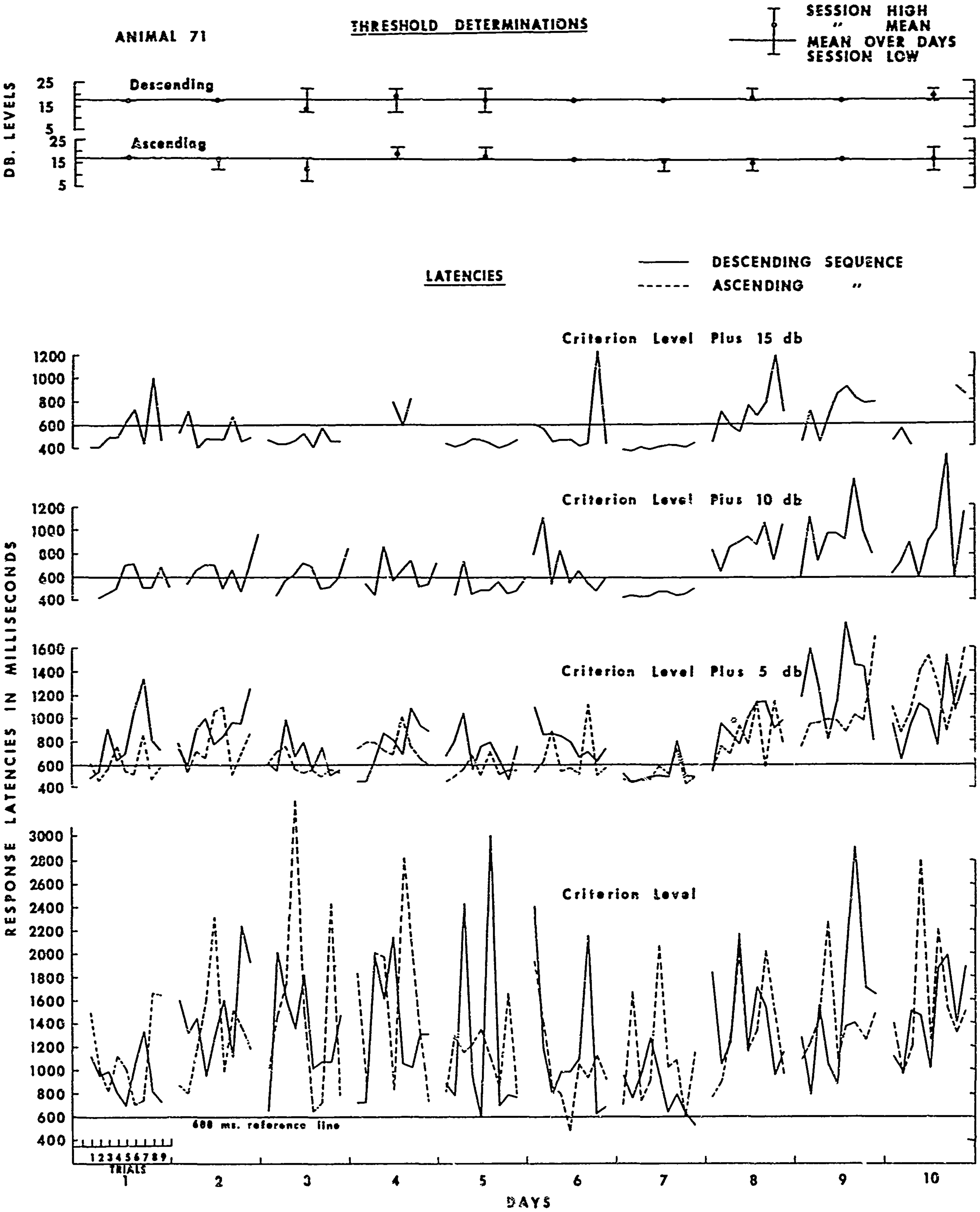

Figure 8. Threshold determinations and latencies of response for successive intensity levels, animal 71.

DISCUSSION

There seems to be a relationship between response latency for a given trial and the events experienced during preceding trials. Woodworth and Schlosberg (5) call this phenomenon an error of habituation. In the descending-intensity sequences, responses had occurred in the immediately preceding trials and the animal may perseverate in making the response on the next trial. In ascending sequences, the usual absense of responses on preceding trials should favor a perseveration of not making a response on the next trial. This perseveration could explain the higher latencies shown by the four animals on the ascending series; as compared to the descending series (Fig. 3).

Occasionally during audiometric testing a constant threshold value will be measured throughout the session when using five dB step attenuation intervals, even though the physiological limen continually changes within the limits of the programmed interval. It would appear that response latency is sensitive to, and reflects, these physiological threshold shifts and thereby gives a better approximation of the absolute threshold. Such important factors as attention, affect, and motivation, the levels of which are constantly changing in the animals during the testing session, would confound such an index. The design of the experiment did not allow an answer to this question.

Measuring latencies during audiometric testing of animals should provide an objective indication of "goodness of performance". The well-trained animal will (though infrequently) give unreliable sensory thresholds by the method of limits. Short latencies (those below an established norm) were observed at the lowest stimulus intensity at which a response was made; this could indicate that the animal should have detected even lower stimulus intensities. Sometimes the animal will "jump the gun", that is, anticipate the onset of tone and respond early. Each animal shows an irreducible minimum latency, and response times shorter than this minimum would be an objective indicator that the trial should be repeated.

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